

Determining behavioral context of whistles in southern resident killer whales, *Orcinus orca*

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## **Introduction:**

Killer whales (*Orcinus orca*) are found throughout the world's oceans in various group sizes, social structures and behavioral patterns. In the northeastern Pacific three main ecotypes of killer whales coexist, fish-eating residents and offshores, and mammal-eating transients. While commonly differentiated by their difference in prey type, these three groups also differ socially, genetically and acoustically (Bigg et al. 1990, Ford 1991, Ford et al. 1998). Further, within the resident population, there are four distinct clans, delineated by their unique vocal repertoires. The northern residents are comprised of A, G and R clans, while the southern residents comprise the J clan. Even more specifically, the J clan is divided into three pods, J, K, and L. Pods are structured through maternal lineage, thus members of each clan are closely related (Ford et al. 2000).

The southern resident clan maintains strong matrilineal bonds. Neither males nor females disperse after birth and instead remain with their mother throughout their lifetime. Pods are thought to interbreed to avoid inbreeding (Ford et al. 2000). Whales habitually frequent the Puget Sound, particularly Haro Strait. This area is rich in nutrients and has a stable presence of salmon throughout the year, with fluctuations in particular species' abundance. Southern residents prey preferentially on chinook salmon, though all species of salmonids have been documented as prey (Ford and Ellis 2006). The southern resident community is further identified by a repertoire of distinct stereotyped calls attributed only to individuals within the clan. The structure and defining qualities of these calls have been catalogued and can now be used to identify clans (Ford 1987, Ford 1991).

Killer whales produce three types of vocalizations, whistles, clicks and calls (Ford 1989). In the resident community, stereotyped pulsed calls have been identified and observers suggest

their use is primarily as long-range contact calls when group members are foraging or traveling (Ford 1989, Miller 2002). Whistles have largely been ignored or marginally mentioned until recent work in the northern resident killer whale community, suggesting that whistles are structurally suited for close-range communication and are predominantly used in close social surface behaviors (Thomsen et al. 2002, Miller 2002, Riesch et al. 2006). While the behavioral context of whistles has been studied in northern residents, it has not been fully undertaken in the southern resident community. Whistles have gained more attention in bottlenose dolphins because of the proposed ability of individuals to identify each other by a ‘signature whistle’ (e.g. Sayigh et al. 1999). Though, these so-called “resident” communities maintain stable social structures as compared to the more fluid social structure of bottlenose dolphins (Ford et al. 2000, Connor et al. 2000) suggesting their patterns of communication might differ accordingly.

This investigation aims to understand the behavioral context of whistles in the southern resident community with particular attention to differences in group spread. I hypothesize that whistles will be more frequently used in close-range communication during social activity than activities occurring over greater distances. These differences might be apparent because of the similarities in close-knit social cohesion the northern and southern resident communities’ share that is not found with other dolphin species.

A more detailed understanding of the communication strategies of the southern resident community may help to better understand the dynamics of their social structure and response to the increase of ambient noise in areas of the Salish Sea in light of the population’s recent listing as an endangered species in November, 2005 (National Marine Fisheries Service). In particular, ambient noise from boat traffic is one potential factor threatening the strength of the population, as well as the increase in vessels associated with whale watching. Changes and patterns in

communication might lead researchers to a more detailed understanding of this particular environmental threat to the Southern Resident community.

## **Experimental Design:**

Data was first collected for two weeks as part of a preliminary data collection phase. Data was collected aboard a 42' Catamaran by six students during daylight hours. During this time both behavioral and acoustic data was collected using continuous sampling. Whales were monitored using the pager network. When whales were within the available area accessible by our vessel, we observed whales under the BeWhaleWise guidelines when possible. The start of a recording session was denoted by first visual confirmation of whales. At that point field notes were recorded to assess the general environment of the day (see Preliminary Data Sheet) was recorded. When our boat approached one kilometer of the group, behavioral observations began. At the beginning of the session predominant group behavior, predominant group spread, number of individuals, and behavioral notes were recorded according to previous behavioral research (Osborne 1986) and personally developed definitions for group spread. Data was recorded at all times while whales are within both acoustic and visual range of the research vessel. All changes in behavior were corded with the time throughout the recording session to be matched with acoustic files. Acoustic data was recorded on our self-named single hydrophone, "The Sperm", deployed from the starboard stern of our vessel. Preliminary tests were conducted to assess the best position, setup, and speeds for the hydrophone to produce high-fidelity recordings. Both behavioral and acoustic data was recorded on a 'real-time' time scale for comparative analysis. Acoustic data was analyzed for call rate during specific 'group spread' categories. Call rate was calculated by finding the number of calls per animal per minute for each recording session. After the preliminary data collection period, methods were personally assessed for feasibility and assessed by instructors and a research panel for validity. We will continue with final data collection for three additional weeks with suggestions from the initial review.

In the primary data collection period, acoustic recordings will be conducted similar to preliminary methods. Our vessel will monitor pager data and attempt to approach groups of whales when feasible. Acoustic recording sessions will start when whales are visually confirmed but still greater than approximately one mile or greater than 15 minutes away. Behavioral observations will begin when the vessel is within 500m of the whales because whistles are best detected within this range due to their source level (Miller 2000, reviewed in Thomsen et al. 2002) and directionality (Thomsen et al. 2001). Group count will be recorded at the beginning of an observation period and monitored every five minutes according to the following sampling protocol. Acoustic data will be sampled continuously during these same periods when whales are within 500m of the vessel from a Marantz digital recorder at 44.1 kHz.

Behavioral observations will include two components. First, group cohesion will be observed under two primary categories when whales surface within 500m of the vessel, close and spread. "Close" is defined as less than one adult male body length apart, roughly 10m. "Spread" is defined as greater than one body length apart. These categories have been used in acoustic studies conducted on resident fish-eating killer whales (Thomsen et al. 2001, Bain, pers. comm.). One body length is the approximate distance in which whales lose two primary modes of communication, touch and sight (D. Bain, pers. comm.), but retain acoustic contact. In addition to distance, the predominant group behavior will also be continuously recorded for the animals within 500m of the vessel. Behavioral states include travel, rest, social, and forage (Osborne 1986). To aid comparison to previous work, behavioral categorizations will most closely follow Thomsen et al. (2002) thus including social traveling as a fifth behavioral state. As a brief overview, foraging is typically non-directional with animals spread over a large distance, marked by irregular surfacings and short, rapid bursts of speed at the surface. Resting

typically occurs at the surface with animals tightly packed, little movement, and little acoustic communication. Traveling is typically directional and at steady speeds on a consistent course. Whales can either be tightly packed (social traveling) or loosely spread. Social behavior is typically marked by close groups and surface behaviors including body contact, sexual interactions, and surface active behaviors (tail slaps, pec slaps, rolls, breaching, chasing, etc.)

These procedures assume a focal-group follow. Observations will end when other animals join or leave the group and data has been collected for at least 30 minutes. Following fission or fusion interactions, a new recording and observation session can begin if feasible for the vessel.

After behavioral observations are complete, we will use Raven 1.2 software for spectrogram analyses (FFT=512 points, sample rate 44.1 kHz, frequency range 0-22kHz) in both the frequency and time domains to assess the presence and number of whistles. The full definition of a whistle is not clearly described in the literature; therefore I will utilize a working definition as described by Thomsen et al. (2001, 2002) and Riesch et al. (2006) for best comparison to data on northern resident killer whales. Whistles are narrow-band tones, with continuous waveforms and can appear with or without harmonics. The frequency ranges from 1.5 kHz-18 kHz but most energy is concentrated within 5-12 kHz. Whistles can last between 50ms and 18s. Qualitatively, whistles sound 'softer' and more akin to the anthropogenic whistle sound, whereas other calls sound more metallic, harsh, or "screech-like".

Whistle rates, the number of whistles per animal within 500m of the boat per minute, will be calculated for each segment of acoustic data denoted by varying categories of group spread and predominant group behavior, e.g. social close, travel close, travel spread, forage spread will each have a unique whistle rate. From these whistle rates, statistical analyses will be conducted

to assess the social significance of whistles.

We expect, from previous work with northern resident killer whales (e.g. Ford 1989, Thomsen et al. 2001, Thomsen et al. 2002, Riesch et al. 2006), that whistle rates will be higher in close proximity affiliations during behaviors such as socializing and will be lower in spread affiliations during behaviors such as foraging and traveling.

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**PREDOMINANT GROUP BEHAVIOR:** (adapted from Osborne 1986, Bain, pers.comm.)

**Forage (for):** typically non-directional, loose spread, slow speed, fish chases and actual prey sometimes visible

**Socialize (soc):** non-directional, often touching, stationary or slow speed, percussive surface behavior

**Rest (rst):** non-directional, often touching or close, slow or stationary speed, often seen at surface in a line as a group or subgroup, or alone 'logging'

**Travel (trv):** directional, average to fast speed, loose or tight spread possible, regular surfacings

**Other (oth):** may include unusual behavioral events or anthropogenic disturbances that might affect whale behavior, spread or acoustic communication.

**PREDOMINANT GROUP SPREAD:**

DISTANCE:

Widespread (wsp):  $>500\text{m}$

Spread (spd):  $\geq 50\text{m}$ ,  $<500\text{m}$

Close (clo):  $\geq 5\text{m}$ ,  $<50\text{m}$

Veryclose (vcl)  $<5\text{m}$

Touching

GROUP:

Individual: one whale  $>5\text{m}$  from any other animal

Subgroup: group of whales less than the total pod size

Pod: One complete family unit with a stable membership

Superpod: J, K and L pod

Group spread is a function of these two parameters:

"Distance" is quantitative while "group" is descriptive and qualitative

Examples:

Individuals widespread= a number of individual animals greater than 500m from any other one animal

Pod close= two pods less than 50m but greater than or equal to 5m apart from each other

Individual/subgroup close: one subgroup less than 50m but greater than or equal to 5m from an individual whale unassociated with subgroup

# Primary Data Collection

**PREDOMINANT GROUP BEHAVIOR:** (adapted from Osborne 1986, Bain, pers.comm., Thomsen et al. 2002)

**Forage (for):** typically non-directional, loose spread, slow speed, fish chases and actual prey sometimes visible

**Socialize (soc):** non-directional, often touching, stationary or slow speed, percussive surface behavior

**Rest (rst):** non-directional, often touching or close, slow or stationary speed, often seen at surface in a line as a group or subgroup, or alone 'logging'

**Travel (trv):** directional, slow to fast speeds, loose spread, regular surfacings

**Social Travel (strv):** travel, but distance between animals <10m

## **PREDOMINANT GROUP SPREAD:**

Spread:  $\geq 1$  adult male body length (approximately 10m)

Close: < 1 adult male body length (approximately 10m)

## **GROUP:**

Whales within 500m of the research vessel

When other individuals join or leave group, a new focal group will be formed

## **Data Collection:**

Recording session #

Date

Observer

TimeStart/TimeStop

AudioFile Number

PhotoFramesStart/PhotoFramesStop

Description of field environment:

Pod(s):

Location:

Weather:

Boat density:

Outside temperature:

Sea state:

OTHER NOTES:

**Continuous Sampling:** Time, count, predominant group activity, spread, pod/matriline, photos

**Appendix: Ethogram + data sheet**  
Adapted from Osborne 1986

BEHAVIOR CLASS	CODE	CATEGORY	DEFINITION
Pod Status (Pod)	ASB POD	Assemblage Pod	More than one pod One complete family unit with a stable membership
	OTH	Other	Less than one pod, lone whale, etc.
Social Units (SocU)	GRP	Grouped	All whales present are in a single homogeneous group
	PSG	Pod Subgroup	An aggregation of 2 or more whales, less than the sum of all whales present, containing members all from the same pod
	MSG	Mixed subgroup	An aggregation of 2 or more whales, less than the sum of all whales present, containing members from more than one pod
	IND	Individual	A single whale by itself
Individual space (IndSpace)	LOO	Loose	Individuals are approximately 5 meters or more apart
	THT	Tight	Individuals are .5-3 meters apart
	TCT	Touching	Whales are in physical contact
Activity level (ActLevel)	FAS	Fast	Moving at approximately 6 knots or more (usually porpoising)
	AVR	Average	4 knots or less
	SLO	Slow	2 knots or less
	STA	Stationary	motionless at the surface
Orientation (Orient)	DIR	Directional	Moving with a nearly constant heading
	NON	Non-directional	Moving without a constant heading
Specific Behaviors (Notes)	SPL	Splashing	Purposeful breaking of the waters surface with an appendage (except following)
	BRE	Breaching	Whale jumps vertically out of water landing with a horizontal splash of at least 1/3 of its body
	SPY	Spy-hop	Whale rises vertically from the water exposing the rostrum and the eyes, whale then slips back into the water in the same vertical plane
	PEN PRY	Penile Prey	Whale observed with erect penis Food species is observed in the mouth or otherwise in the immediate vicinity
Acoustic environment	SIL	Silence	Individual are not producing any phonations
	CLK	Echolocation Clicks	Individuals are producing echolocation clicks and no other types of phonations
	WHI	Whistles	Ind. producing whistles and no other types of phonations
	CAL	Calls	Ind. producing pulsed calls and no other types of phonations
	MIX	Mixed	Ind. producing a variety of clicks, whistles and calls
Individual comments (recorded within Pod Status)	M	Male	Adult male
	F	Female	Adult female
	C	Calf	Small young whale usually accompanied by adult female





